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**Differentiated management of GM diffusion in China:
Further hampering the self-sufficiency in cereal production?**

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Résumé

La Chine est un grand pays dans le domaine des biotechnologies mais c'est aussi l'un des rares pays à manifester une politique différenciée dans la diffusion des OGM en fonction des cultures. Alors que la diffusion est autorisée notamment sur le coton depuis 1998, elle reste encore interdite sur les cultures vivrières. En dépit des résultats positifs obtenus sur le coton, au moins à court terme, et de la persistance de la réduction de la production de céréale, l'hésitation dans l'utilisation des OGM sur les cultures vivrières devrait perdurer, non sans fondement, car la dimension qualitative de la production alimentaire doit être prise en compte.

Abstract

China is a big country in terms of biotech achievements. It is also a rare country demonstrating crop-differentiated policies in the dissemination of the GMOs. While the release of GMOs is authorized notably for cotton in 1998, it is still prohibited for food crops. In spite of the positive outcomes on cotton, at least in the short run, and of the persisting decrease of the cereal production, the hesitation to release GMO on food crops should keep on prevailing. This seems to be founded when the qualitative dimension of the food production is taken into consideration.

Mots clés: Chine, OGM, sécurité alimentaire, coton, cultures vivrières, productivité

Key words: China, GMO, food security, cotton, foodcrops, productivity

1. Introduction

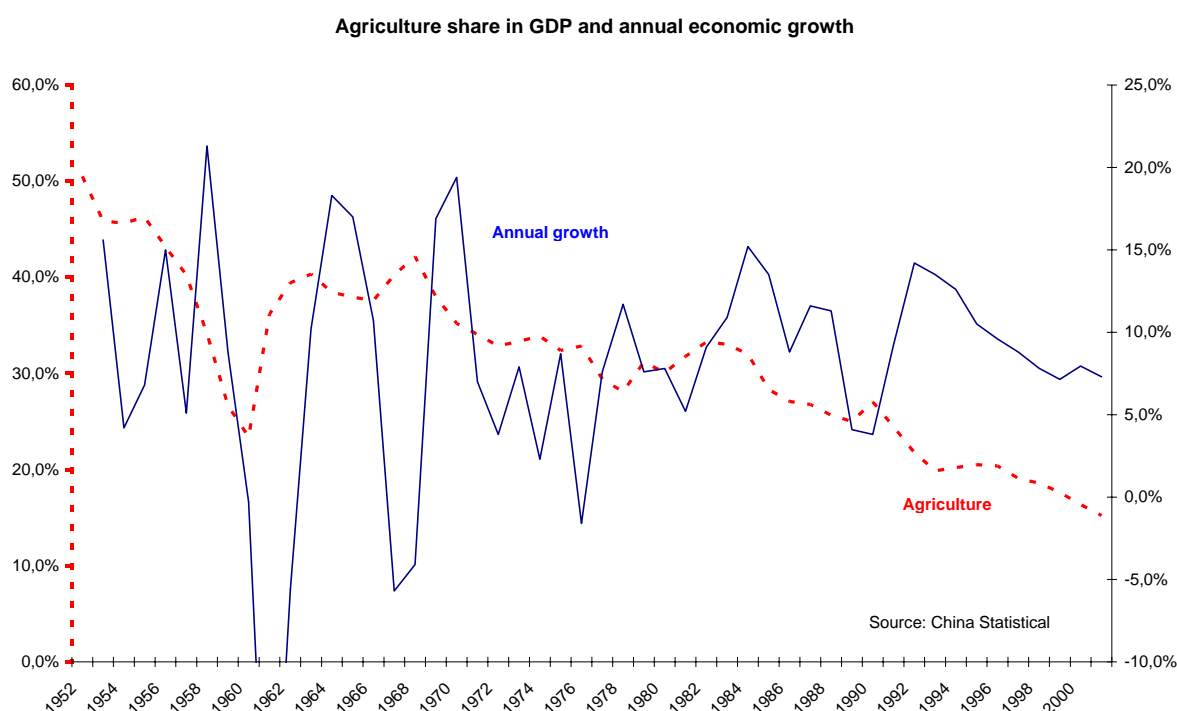
After the launch of the economic reform in 1978, China is experiencing a continuous high-level economic growth whose annual rate reached frequently two digits. This continuous growth takes place along a dramatic change in the structure of the Chinese economy. The agriculture sector¹ declined continuously short after the Economic Reform, in compliance with the economic theory (Anderson, 1987): it accounts only for 15% of the Chinese GDP or

¹ called "Primary industry" in China and encompassing farming, animal husbandry, forestry and fishery.

the half of its level at the beginning of the 1980s (Figure 1).

This continuous growth induced an increase of the families' income which became substantial around ten years after the Economic Reform. A phenomenon of income differentiation clearly came out, firstly between the urban and the rural households. Roughly speaking, the average income of the urban household is around 250% of the one of the rural families (Figure 2). Very poor families appear both in the cities and the rural townships. In spite of the official claim of a socialist market economy, China has not succeeded in preventing the emergence of extreme poverty along with economic growth, and this contradiction seems to be accepted by most people in China². How to keep the income gap at an acceptable level is probably the challenge to overcome for the Chinese Government. Many, if not all countries in the world have so far failed, how China will handle the issue at the scale of its huge population of 1.3 billions deserves nevertheless more attention and empathy than criticism and sarcasm.

Figure 1. The decline of agriculture along the economic growth



In spite of the accelerated differentiation mentioned above, the favourable trend of the income increase during twenty years has concerned a large part of the population. This income increase induced clearly a modification of the Chinese diet with some features which are China-specific. If the decrease in the consumption of cereal is common to what is generally observed, this is less the case for the decrease of the consumption of vegetables and

² We personally observed that beggars or homeless people, elderly people without neither family nor social support attract the attention of no one in the underground passage of the Tian An Men square in Beijing. The same was noticed along the avenues of the downtown of Nanjing.

furthermore for the one of sugar. The increase of the consumption of meat is clear but in China, it is observed for all production of animal source except for the pork (Table 1).

Figure 2. Income Increase and differentiation

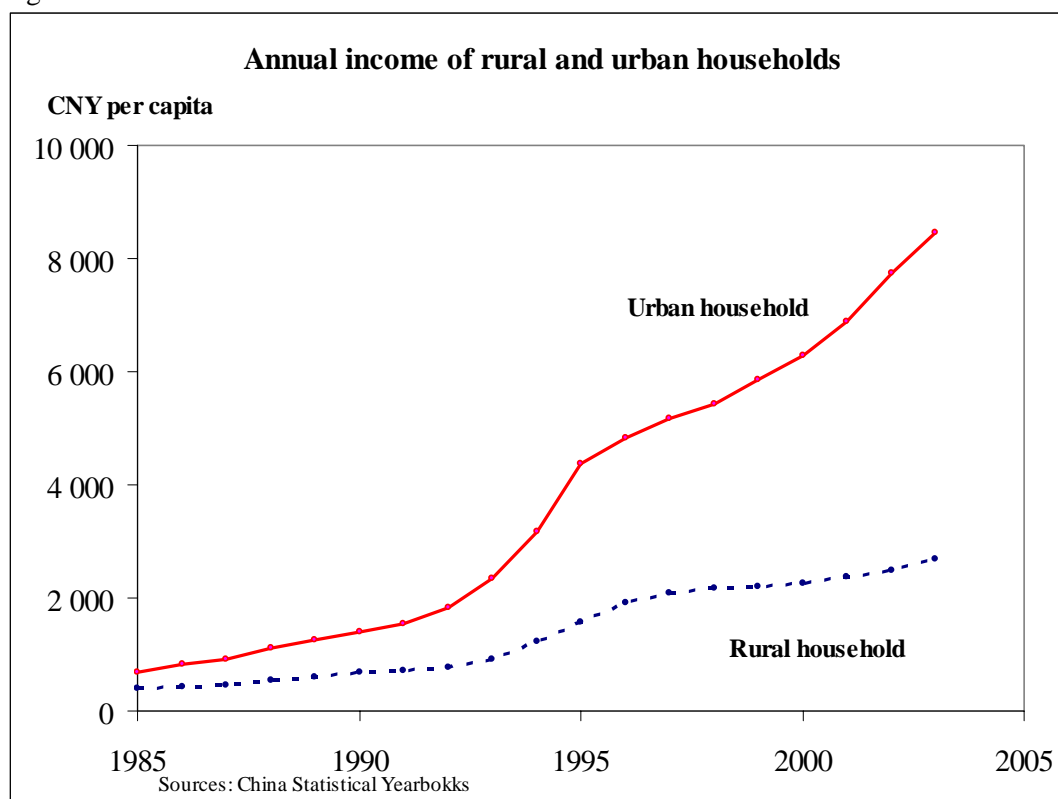


Table 1. Mainly classical change in the diet of the Chinese urban population

	1985	1990	1995	1999	2000	2001
Cereal (kg)	134,76	130,72	97	84,91	82,31	79,69
Vegetables (kg)	144,36	138,7	116,47	114,94	114,74	115,86
Edible oil (kg)	5,76	6,4	7,11	7,78	8,16	8,08
Pork (kg)	16,68	18,46	17,24	16,91	16,73	15,95
Beef and mutton (kg)	2,04	3,28	2,44	3,09	3,33	3,17
Poultry (kg)	3,24	3,42	3,97	4,92	5,44	5,3
Eggs (kg)	6,84	7,25	9,74	10,92	11,21	10,41
Aquatic products (kg)	7,08	7,69	9,2	10,34	9,87	10,33
Sugar (kg)	2,52	2,14	1,68	1,81	1,7	1,67

Source: China Statistical Yearbooks

The animal productions increased a lot during the last twenty years but insufficiently to cover the national needs: the value of the importation of various meats decupled during the last decade (Table 2). The production of animal feed has represented a substantial use of the cereal produced in China: this is a phenomenon which might accentuate the Chinese dependency on the world market and imply price fluctuation/increase. This has led to question "who will feed China" (Brown, 1991, Brown, et al., 1996) and which induced frequently touchy, albeit justified reaction³ in China (Fu, et al., 1997, Kang, 2003).

³ The Chinese scholars reacted strongly against the claim that the Chinese food issue will induce directly

Table 2. Increase of meat production and importation

	Output of meat, animal products			Meat Import
	Total	pork, beef, mutton	poultry eggs	value
	10000 t	10000 t	10000 t	Million \$
1978		856		
1980		1 205		
1985	1 927	1 761	535	
1986	2 112	1 917	555	
1987	2 216	1 987	590	
1988	2 480	2 194	696	
1989	2 629	2 326	720	
1990	2 857	2 514	795	
1991	3 144	2 724	922	
1992	3 431	2 941	1 020	57
1993	3 842	3 225	1 180	68
1994	4 499	3 693	1 479	85
1995	5 260	4 265	1 677	95
1996	4 595	3 695	1 965	157
1997	5 269	4 250	1 895	149
1998	5 724	4 598	2 019	143
1999	5 949	4 762	2 135	499
2000	6 125	4 838	2 243	637
2001	6 334	5 026	2 337	598
2002	6 587	5 228	2 463	627

Source: China National Bureau of Statistics

The issue of the Chinese dependence on the world market to feed itself is more complex than it might appear from the gap between the production and the consumption in China. The figures of the Chinese importation of cereal during the recent years do not confirm the L. Brown's prediction: there was a decreasing trend of the importation⁴ while the combined exportation of cereal and flour augmented (Table 3). China, a matter of tradition, is deeply involved in the production of much diversified agro-foods and their exportation is of great economic importance. The size of the Chinese Diaspora all over the world ensures outlets for the Chinese agro-foods but this Diaspora is no longer the unique outlet of these foods.

Table 3. Import & Export of cereal and flour in China (1000 tons)

	Export	Import
1997	8 330	4 170
1998	8 880	3 880
1999	7 380	3 390
2000	13 780	3 150
2001	8 760	3 440
2002	14 820	2 850

Source: China Statistical Yearbooks

negative impacts on the world. First, through the price increase implied by the Chinese demand, many developing countries will no longer afford buying food on the world market and which find themselves worse off. Second, through the temptation to increase offer in order to meet to Chinese demand, natural resources could be excessively exploited. In short, the Chinese scholars protested against a new presentation of the "péril jaune".

⁴ What makes the analysis arduous is the high level of the cereal stock in China and whose management could lead to export even though the production is short with regard to the domestic demand.

The issue of the Chinese food sufficiency is complex and we do not claim addressing it from a global perspective. The target of this paper is to contribute clarifying the impact of the emergence of Genetically Modified Varieties (GMVs) on the issue by making use of the results of a recent survey to complete the existing data. This survey was conducted in 2003 in Hebei Province, northern China, along the Yellow River valley, with the aim of determining the farmers' cultivation practices and the economic results generated by using the cotton GMVs in connection with farm structures, the farmers' command in the management of the chemical control of cotton pest, and their feelings regarding the efficiency and sustainability of the GMV use. The survey covered 228 farms in seven counties in the five most important cotton production districts of the province (Cangzhou, Handan, Hengshui, Shijiazhuang and Xingtai).

We argue that the issue of the Chinese cereal sufficiency is made more critical with the GM emergence owing to the differentiated management of their diffusion at the expense of the food crops. We doubt nevertheless that the correction of the current disequilibrium in the release of the GMVs will be sufficient to reverse the trend of stagnant/decreasing cereal production. Wholly speaking, we anticipate that the Chinese interaction with the World market, a notion we favour instead of its dependence, will become stronger.

In this paper, the Part 1 provides an insight on the current diffusion of GMVs, emphasizing the differentiated use of the GM research outcomes. The Part 2 analyses the extent and the factors of the successful diffusion of the GMVs on cotton. The Part 3 analyses the profitability gap at the expense of the cereal production, furthermore after the adoption of the cotton GMVs (at least as far as the cotton producing provinces are considered). The Part 4 deals with the Chinese precaution in releasing GMVs for foodcrops and why this release would remain of limited impact to boost again the cereal production.

2. Differentiated use of the GM research outcomes

2.1. *China: a second big country in biotech research*

Although the diffusion of GMVs in the world is generally associated to US multinational firms like Monsanto, it is not correct to perceive the USA as the unique country having reached outcomes at the dissemination stage. During the 1996-2000 period, the Chinese Office of Genetic Engineering Safety and Administration approved 251 cases of GM plants, animals and recombined microorganisms for field trials or commercialisation (Teng, et al., 2004). The research institutes in China have committed with biotechnology works since the beginning of the 1980s and these works were enhanced within the framework of the "863" Plan, and later on the "973" Plan, which enabled the Chinese research teams to identify many

genes, to build new specific gene constructions of their own and to master an original method for gene transfer through the pollinic tube. A Chinese research team is the owner of a new Bt gene construction, based upon sequences controlling Cry 1B and Cry 1C toxins, and this is the gene used in all Chinese Bt cotton varieties we mentioned earlier. China also launched, more or less at the same time as Monsanto, a new variety with dual-gene resistance to bollworms (SGK 321) by combining a Bt gene and a protein inhibition gene. The impact of this combination of two distinct effects on the pest to control could potentially be more sustainable than just combining two Bt genes as Monsanto did.

China is particular in its biotechnology research works in the sense that they are not concentrated on a limited number of crops. About eighteen crops are involved, including industrial crops, food crops, vegetables and flowers⁵ (Huang, et al., 2003b). Nowadays, the dissemination is only authorised on four crops (cotton, tomato, sweet pepper and petunia), in spite of the fact that China was the first country to have allowed the commercialisation of GMVs. This historic background is worth being reminded for the purpose of this paper. The commercialisation of tobacco GMVs started in 1992. It took place in the implementation of a contractual production for the US firm Philip Morris. In response to the concern of the US consumers about smoking GMO, Philip Morris decided to stop using tobacco derived from GMVs. This decision led to an abrupt interruption, in 1995, of the use of the tobacco GMVs in China. This experience should have taught the Chinese Government that the consumers' reaction matters, in particular when it has no control at all on the consumers' preference from abroad.

2.2. *Large-scale adoption of cotton GMVs*

Although the use of GMVs is not limited to cotton, it is the dissemination of the cotton GMVs in China which specifically captures the attention to this country. One reason is that this use is covering a large area. Although there is no official compilation, it is estimated that cotton GMVs are covering 45% of the cotton area in the country⁶ and are exclusively used in some provinces like Hebei⁷ (Table 4). This is the reason why the adoption of GMVs on cotton tends to be associated to a re-birth of the production in these provinces.

Historically, Hebei province has contributed significantly to the Chinese cotton production. The development of strong resistance to insecticide from the cotton bollworm *Helicoverpa*

⁵ Cotton, tobacco, tomato, rice, wheat, soyabean, peanut, sweet pepper, petunia...

⁶ The release of the cotton GMVs is not authorized in all cotton provinces

⁷ Chinese cotton producers are not requested to install refuge plot in order to prevent from the occurrence of resistance to Bt-toxin. Compliance to this prevention measure can hardly be expected owing to the very small size of the farm holdings (on average 0.7 ha). The relevance of the necessity of this measure is also debatable in the context of the neighbouring presence of non-cotton crops that can ensure the refuge role.

armigera, in the early 1990s, stalled the progress of this production (Table 5). The continuation of cotton production was threatened and the challenge was to find an effective technical solution. Hebei Province was the first province where Bt-cotton varieties were disseminated, which eventually led to a remarkable rebirth of cotton production in this region. Nevertheless, the conditions of the diffusion of the cotton GMVs are worth being reminded in order to clarify the role of foreign biotech firms.

Table 4. Evolution of the area in GM cotton in China (10³ ha)

	All provinces			Hebei Province		
	All cotton	GM cotton	% GM	All cotton	GM cotton	% GM
1997	4 491	34	1%	377	13	3%
1998	4 459	261	6%	315	175	56%
1999	3 726	654	18%	266	227	85%
2000	4 041	1 216	30%	307	298	97%
2001	4 800	2 174	45%	418	410	98%
2002	4 480	1 943	43%	407	403	99%

Source: Huang Jikun et al. and authors' compilation

Shortly after the appearance of strong endemic resistance of the bollworm (*Helicoverpa armigera*) against insecticides in the early 1990s, the need for a genetic solution became clear and Chinese institutions have tried to disseminate bollworm resistant varieties since 1994 without real success (Pray, et al., 2001). The reasons for this failure have yet to be seriously analysed but go beyond the scope of this paper. This historic background deserves to be mentioned since Monsanto moved to conquer the Chinese market somewhat in response to a real Chinese need after experiencing failure. Hence, it would not be fair to interpret Monsanto's entry just as an illustration of a unilateral move by a powerful multinational firm.

Table 5. Cotton production patterns in Hebei Province (10³ tons of lint)

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Hebei	511	626	577	536	571	634	306	192	390
National	3541	4245	4149	3788	4507	5673	4510	3739	4342
Production share	14,4%	14,8%	13,9%	14,2%	12,7%	11,2%	6,8%	5,1%	9,0%
	1995	1996	1997	1998	1999	2000	2001	2002	2003
Hebei	370	258	249	270	223	298	419	402	522
National	4768	4202	4603	4501	3828	4417	5320	4920	4870
Production share	7,8%	6,1%	5,4%	6,0%	5,8%	6,7%	7,9%	8,2%	10,7%

According to our survey, there are nowadays more than twenty cotton GMVs in Hebei Province, out of which only two were introduced by Monsanto. This is consistent with what was observed in the same province in a former survey two campaigns earlier (Huang, et al., 2003b). Many Chinese cotton GMVs are grown, they were carried out by research organisms of various administrative levels (Table 6). The US varieties are still having the biggest market share, in terms of number of farmers using them and of cotton area concerned (Table 7 and Table 8). This situation should evolve in a near future because the new Chinese cotton GMVs are combining various genes, consolidating the resistance to the cotton bollworm and

providing resistance to one or two diseases. We observed that 35% of the farmers are growing more than one variety; this is an indication that no variety has yet won their loyalty.

Table 6. Number of Bt cotton varieties according to the geographic level of their origin

Level of origin	Type of varieties		
	Open-pollinated	Hybrid	Total
International	2		2
National	9	1	10
Provincial	4	1	5
Districtal	2	3	5
unclear	6		6
Total	23	5	28

Source: our survey

Table 7. Distribution of the numbers of farmers according to the origin of the Bt cotton they used

Variety type	Origin	2002	2003
Open-pollinated	Chinese	63	109
	USA	146	128
Hybrid	Chinese	9	15

Source: our survey

Table 8. Market share of the Bt-cotton varieties by origin according to the area grown (in mu)

Origin	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zhuang	XiJing Ke	Total
Chinese	37	178	47	115	141	518
USA	50	16	289	159	123	636
Total	87	194	336	274	264	1154

Source: our survey

2.3. *Reluctance in releasing GMVs on cereal crops*

The Chinese research teams achieved also remarkable outcomes in their biotech works on cereal crops like rice, wheat and maize. In the case of rice, a large range of GMVs are available which integrate various types of resistance genes. There are varieties resistant to insects like the stem borer and plant hopper. Other varieties are resistant to diseases or virus (Huang, et al., 2003b). Varieties resistant to herbicides are available, but the varieties resistant to drought or saline soils could be regarded as the most commendable outcomes. For wheat, there is similarly large range of GMVs.

In spite of the availability of many GMVs for the main cereal crops, the Chinese Government has not yet authorised their release and there is little sign that this precaution could end up in the near future. There was no additional authorisation of GMVs since the year 2000 (Huang, et al., 2003a, Teng, et al., 2004). Few foreign observers take actually note of the hesitation in releasing new GMVs but they believe that this is only a strategic hesitation destined to let enough time for the Chinese scientists to catch up the performance level of the foreign GMVs (Macilwain, 2003). With regard to the diversity of the types of GMVs and of the crops concerned by the biotech research works in China, we think this reason is a minor one.

The concern of the consumers in foreign countries with regard to GM food, in particular in Europe, cannot be overlooked for an exporting country of agro-foods such as China. This is furthermore true since China got a first warning on how the implication could be. In 2000, the United Kingdom announced the suspension of the importation of the soy sauce from China arguing that this sauce might be produced from US soybeans which result mainly from GMVs (Anon., 2001a). This episode is at the origin of the labelling of the bottles of soy sauce one finds in Europe with the GMO-free indication. The consumers' concern regarding the GMO issue is recently legalised by the decision of the European Union to render compulsory the labelling of GMO content on any agro-food.

3. The Extent and the factors of the successful diffusion of GM on cotton

The diffusion of cotton GMVs in China is so far successful owing to their effectiveness in controlling the targeted pest at low cost. The additional profitability which results is furthermore enhanced by attractive price which derives from the control of the cotton importation decided by the Chinese government.

3.1. *Bt cotton efficient in controlling pests so far*

The efficiency of Bt cotton cropping is first shown by the high cottonseed yields, in compliance with the average yield obtained in Hebei Province. The low standard deviation (SD) also indicates that the average yield is quite representative of the yields that all farmers actually achieved (Table 9). In all villages where it was possible to collect figures for two crop seasons, the yield decreased in 2003 although the extent varied. This is consistent with what was observed throughout Hebei Province or along the Yellow River valley, a phenomenon that most observers attributed to heavy rains at the end of the season.

Table 9. High seedcotton yields (averages and SD in kg/ha)

	Surveyd Villages						
	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zuang	XiGuan	XiJing Ke
2002	3625 (233)	3914 (201)	3424 (261)	4204 (399)	3876 (219)	2855 (436)	3546 (398)
2003	3032 (444)		3346 (173)	3691 (378)	3763 (75)		3015 (462)

Source: our survey

The average yield was achieved with total numbers of insecticide sprays ranging from 4 to 15 in the 2002 crop season, with two villages having a significantly lower figure (Table 10). This total number did not vary the following season, although a slight decrease was observed in one village. This result is consistent with previously reported figures (Huang, et al., 2003a, Pray, et al., 2002) and indicates that there was a decrease in the number of sprays used to control bollworms.

When considering the breakdown of insecticide sprays according to the pests targeted, it turns out that bollworm control still required an average of four to five sprays with little between-

season variation (Table 11). It should be stressed that aphid and red spider control required more sprays overall, with no clear indication of an increasing number of sprays in all villages during the last season.

Table 10. Total number of insecticide sprays

	Surveyed villages					
	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zhuang	XiJing Ke
2002	15,3	9,0	18,3	11,2	4,2	15,6
2003	9,8	8,3	15,2	13,6	5,0	15,0

Source: our survey

Table 11. Breakdown of the total number of insecticide sprays according to the pest controlled

		Surveyed villages					
		Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zhuang	XiJing Ke
2002	Against Aphids	7,7	3,0	5,2	3,8	2,3	5,6
	Against bollworms	5,4	3,5	7,4	4,2		5,0
	against red spider	4,3	2,5	2,0	3,2	2,0	5,0
2003	Against Aphids	3,5	3,0	9,8	4,6	2,5	5,2
	Against bollworms	5,5	3,1	3,5	5,4		5,4
	against red spider	3,3	2,3	2,4	4,0	2,5	4,5

Source: our survey

The farmers were found to be happy with the efficiency of Bt cotton in controlling pests, only 12% of them did not find Bt cotton to be efficient (Table 12). The main reason is that the farmers knew that Bt cotton targets only bollworms (Table 13).

Table 12. Distribution of the number of farmers according to their opinion on the efficiency of GMC in controlling cotton pests.

	Surveyed villages							Total
	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJiaBao	Song Zhuang	XiGuan	XiJing Ke	
Good	17	14	17	26	21	30	6	131
Ordinary	11	11	8	6	3	4	1	44
Not good	1	1	1	0	1	4	17	25
Total	29	26	26	32	25	38	24	200

Source: our survey

Table 13. Distribution of farmers' opinions according to the pest that Bt cotton can control (percentage of farmers surveyed)

	Surveyed villages								Total
	Chen Zhuang	DaWang Zhuang	Fang Ya	Liang Mian Chang	ShiJia Bao	Song Zhuang	XiGuan	XiJing Ke	
aphid	3%	0%	0%	0%	6%	0%	0%	10%	3%
Bollworm	93%	100%	92%	100%	94%	96%	95%	80%	93%
no idea	0%	0%	4%	0%	0%	0%	0%	0%	0%
red spider	3%	0%	4%	0%	0%	4%	5%	10%	4%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: our survey

3.2. *The cost of procuring Bt cottonseed remains acceptable or even low*

The cost for Chinese farmers to procure Bt cotton appears to be far lower than in other countries. More than 50% of the farmers used, either partly or totally, the seeds they held back from the previous season (Table 14), at a cost that was likely close to zero. This phenomenon of holding back seeds is a long-standing custom of Chinese farmers. In our

survey, the farmers declared that this phenomenon could not have a negative impact on efficiency, provided that the seeds are renewed every 2-3 years. We identified 50 farmers (22% of the sample) who declared that they had no seed costs. Table 15 shows the average Bt cottonseed prices for farmers who bought at least part of the volume they used (prices in Yuan, approximate exchange rate being one € for 10 Yuan) , and these values could be explained by the fact that part of the seeds were held back at low cost, if any.

The unit price for seeds did not vary as much. Seeds of the Chinese varieties, at least for the non-hybrids, were around 30% less expensive than the American seeds but it seems that the price gap for similar varieties is diminishing. Some farmers used hybrid seeds, whose price was higher than open-pollinated ones, but still lower than the American varieties. The prices increased during the last season, a trend that could be interpreted as the result of farmers' acknowledgement to the values of the Bt cottonseed while the competition of the Chinese varieties could no longer be associated only to their lower costs. The seed dosages used for planting (Table 16) did not vary between the varieties used, i.e. 18-19 kg/ha (this figure is much higher than the usual 12-15 kg/ha dosage), except for the Chinese hybrids for which the farmers reduced the amount used. The overall cost of the seeds was around 25% of the total cost associated with the cash-expense inputs.

Table 14. A widespread phenomenon of the farmers holding back seeds

	Distribution of the farmers' answers according to the number of varieties used			All farmers
	1	2	3	
Seed obtained from exchange	1%	0%	0%	1%
Seeds are partly bought and holdback	26%	29%	75%	30%
Seeds are totally bought	53%	33%	0%	45%
Seeds are totally holdback	20%	38%	25%	25%
Total	100%	100%	100%	100%

Source: our survey

Table 15. Unit prices for Bt cotton (yuan/kg)

Origin of varieties	Type of varieties	Campaign	
		2002	2003
Chinese	Non-hybrid	27,4	37,1
	Hybrid	40,0	45,0
USA	Non-hybrid	41,1	50,7

Source: our survey

Table 16. Seed dosage (kg/ha)

Origin of varieties	Type of varieties	Campaign	
		2002	2003
Chinese	Non-hybrid	19,4	19,0
	Hybrid	19,5	13,1
USA	Non-hybrid	18,9	18,2

Source: our survey

3.3. *Cotton growing is profitable*

Growing Bt-cotton proved to be profitable to farmers. After deduction of the chemical input costs, which are the main part of the cash expenses for the farmers, the remaining income (Table 17) ranged from 10000 to 15000 yuan/ha in the 2002 season, and significantly higher in 2003 (from 13000 to more than 18000 yuan/ha). The financial profitability of growing cotton was further confirmed by the output/input ratio, which was far higher than the commonly accepted 2.5-3.0 threshold (Table 18). These values of ratio result directly from the high level of the yield achieved and the relative prices of the inputs and output which are opposite to what is observed commonly in developing countries. The slight variation in the average yield, as we underlined earlier, further indicated that there was little risk associated with this financial profitability.

Table 17. Cotton net income after deduction of chemical input expenses (yuan/ha)

	2002	2003
Chen Zhuang	13 228	17 438
DaWangZhuang	14 848	
Fang Ya	10 591	14 414
ShiJiaBao	12 937	18 369
Song Zhuang	11 173	19 828
XiJing Ke	11 829	14 664
All villages	11 798	17 093

Source: our survey

Table 18. Output/input ratio in growing cotton

	Surveyed villages					
	Chen Zhuang	DaWang Zhuang	Fang Ya	ShiJia Bao	Song Zhuang	XiJing Ke
2002	6,9	7,9	5,3	6,5	5,1	5,8
2003	8,8		6,3	6,9	8,2	6,7

Source: our survey

All the surveyed farmers planned to keep on growing Bt cotton, and most of them were considering growing more Bt cotton, generally for reasons related to the higher expected profitability.

3.4. *Profitability derived from favourable diffusion rules*

Although most of the results of the analysis seemed to associate the adoption of Bt cotton with its intrinsic advantages, we believe that two complementary factors matter in China, both pertaining to institutional arrangements (Fok, et al., 2004). Profitability is firstly ensured by the conditions established in launching Bt cotton, so that the cost associated with its use is thus acceptable. In China, farmers have benefited from rules for using Bt cotton, which differ substantially from those imposed in other countries. Secondly, the financial risk linked to the higher production cost is mainly managed through control of cotton lint imports from the world market. By somewhat isolating the Chinese market even though there is high demands from the national textile industry, the Chinese government contributes to sustaining a high

purchase price for farmers' cotton.

Everywhere Bt-cotton is introduced, mainly by the American firm Monsanto, the payment of technology fees and the formal contractual commitment to not hold back seeds (via any vegetative form) are two institutional arrangements which are imposed without much debate. The technology fees, in addition to the seed cost, is around US\$ 60/ha nowadays after having reached up to US\$ 90. The very formal contractual arrangement and the application of the rules in countries where contracts are actually enforceable gave rise to great publicity concerning cases of violations with decisions made in favour of the biotech and seed companies (notably in Canada and the USA).

China succeeded in imposing a totally different set of rules by preventing the set up of a monopolistic situation from the American firms. In 1996, these firms were invited to endorse a joint venture with the Hebei Seed Company, while another Chinese firm, in collaboration with the Chinese Academy of Agricultural Sciences, was installed. Bt cotton seed is supplied under conditions that prevail in Western countries for common seeds. Seeds are only bought and there is no requirement for farmers to sign a contract and make a commitment to follow special cultivation techniques (like refuge plot to prevent the emergence of resistance by the targeted pest to the Bt toxin). The prices farmers pay are all inclusive, with no distinction or mention of any technology fee.

If the Chinese farmers benefit in one side of specific rules which keep the use of the cotton GMVs at reasonable cost, they take advantage in the other side of attractive price for the cotton they produced.

As a condition to obtaining US support for its entry into the WTO, the Chinese government accepted to give up most of the different forms of domestic support given to farmers. In spite of this direct subsidy abolition, Chinese farmers still benefit positively from isolation from the world market price since the importation of cotton lint from the world market is still strongly controlled by the central government (Weathersby, 2002). As a consequence, farmers sold their cottonseed and obtained a farm gate price equivalent to US\$ 0.66/pound and 0.89/pound of cotton lint in 2002 and 2003, respectively, whereas the world market price was US\$ 0.46 and 0.63 from the CIF Northern Europe position. This price level makes cotton production very attractive and profitable, as we pointed out earlier, and reduces the financial risk in using Bt cotton despite the additional seed cost.

4. Cereal production further loosing ground

In the area where our survey was conducted, farmers are growing essentially cotton, wheat and maize; these two cereals are very frequently grown sequentially and sometimes relay-

cropped. In analysing the results of the survey, we observed that few farms have got into some specialisation at the expense of the cereal production. Farmers are seldom devoting less than 40% of their cultivated land to cotton. This is an indication that cereal production is loosing ground against cotton. This is a phenomenon which is quite illustrative of what occurs in China in general and which results from the reduced profitability of the cereal production, in particular wheat, and to a lesser extent, maize. We put aside the rice case which is not really produced in the Province we surveyed.

4.1. *Decreasing Cereal production under structural change*

Wholly speaking, the evolution of the production of wheat and maize has been unsteady during the last fifteen years, both at the national level and in Hebei Province. The acreage devoted to maize and wheat decreased till 1994, but it augmented again till 1999 before decreasing again (Table 19). As the very severe cotton pest resistance to chemicals occurred in 1993 and the large adoption of cotton GMVs became real after 1998, the evolution of the acreage destined to maize and wheat might have been influenced by the security of the income in growing cotton. From this perspective, this is a sign that the introduction of GMVs on a competing crop (cotton) impacted very quickly and negatively on the cereal production, notably on the cereal acreage since the year 2000 (Table 20). In terms of the relative shares of wheat and maize, it comes out that maize caught up wheat and their respective acreages are very close. Since maize is more productive, the maize production is significantly higher than the wheat production at the national level. In Hebei, a typically wheat region, the maize production has just come close to the wheat production. The evolution of the maize production can be regarded as an indication of the demand for animal feed for which maize is often an essential raw material.

Table 19. Acreage reduction in cereal growing (10³ ha)

	All Provinces			Hebei		
	cereal	wheat	maize	cereal	wheat	maize
1978		29 183	19 961			
1980		28 844	20 087		2 855	2 341
1985		29 218	17 694		2 649	1 750
1989		29 841	20 353			
1990		30 753	21 401		2 352	2 041
1991	94 073	30 948	21 574	5 840	2 508	2 056
1992	92 520	30 496	21 044	5 664	2 542	1 987
1993	88 912	30 235	20 694	5 789	2 525	2 129
1994	87 537	28 981	21 152	5 596	2 456	2 104
1995	89 310	28 860	22 776	5 767	2 501	2 291
1996	92 208	29 611	24 498	6 069	2 591	2 525
1997	91 964	30 057	23 775	6 068	2 721	2 426
1998	92 117	29 774	25 239	6 244	2 764	2 581
1999	91 617	28 855	25 904	6 231	2 730	2 664
2000	85 264	26 653	23 056	5 879	2 679	2 479
2001	82 596	24 664	24 282		2 580	2 543
2002	81 466	23 908	24 634		2 450	2 577
2003					2 192	2 488

Source: China Statistical Yearbooks and statistics from the Hebei Provincial Government

Table 20. New phase of reduction in cereal production (1000 tons)

	All Provinces			Hebei		
	cereal	wheat	maize	cereal	wheat	maize
1978		53 840	55 945			
1980		55 205	62 600		3 788	6 632
1985		85 805	63 826		7 443	6 789
1989		90 807	78 928			
1990		98 229	96 819		9 277	8 292
1991	395 663	95 953	98 773	20 720	9 004	9 061
1992	401 696	101 587	95 383	20 090	9 179	8 343
1993	405 174	106 390	102 704	21 364	9 021	9 651
1994	393 891	99 297	99 275	22 633	9 217	10 653
1995	416 116	102 207	111 986	25 070	10 603	11 834
1996	451 271	110 569	127 471	25 571	11 391	11 684
1997	443 493	123 289	104 309	25 541	13 307	10 095
1998	456 247	109 726	132 954	26 803	12 356	11 872
1999	453 041	113 880	128 086	25 521	12 805	10 880
2000	405 224	99 636	106 000	23 556	12 080	9 945
2001	396 482	93 873	114 088	23 090	11 227	10 595
2002	397 987	90 290	121 308		10 950	10 350
2003					10 184	10 630

Source: China Statistical Yearbooks and statistics from the Hebei Provincial Government

4.2. *Comparatively low profitability of the cereal production*

China liberalized the cereal market at the beginning of the 1990s. No more official price was set up and there was no longer obligation for the farmers to sell to the governmental commodity offices at pre-determined prices: farmers got the freedom to sell directly to the market whenever and wherever they wanted. The fact that farmers withdrew somewhat from cereal production indicates that the profitability did not increase as much as expected from the liberalisation process.

It is not very clear that the profitability in growing maize or wheat was constrained so much by an unfavourable yield trend. Yield was maintained during the last ten years and when considering the case of wheat, one could say that yield has increased to some extent (Table 21). Although the precision of the official statistics are questionable, in particular if we refer to our survey which showed higher yields (Table 22), we think that the evolution pointed out should be valid.

The evolution of the prices and in particular of the price ratios has been more crucial in determining the structural change which took place between the cereal production (maize and wheat) and cotton in one hand, and, in the other hand, between the two cereal involved.

Very clearly, the price ratio between wheat and maize has decreased at the expense of wheat while maize has higher yield (Table 23). This evolution should account in the shift in favour of maize. The shift in favour of cotton growing results from the same phenomenon. It can be observed the price ratio in favour of cotton during the last ten years has been far higher -with

the exception⁸ of 2001- than the one when the commodities prices were administered to promote cereal production.

Table 21. Evolution of maize and wheat yields (kg/ha)

	All Provinces			Hebei		
	cereal	wheat	maize	cereal	wheat	maize
1978		1 845	2 803			
1980		1 914	3 116		1 327	2 833
1985		2 937	3 607		2 810	3 881
1989		3 043	3 878			
1990		3 194	4 524		3 944	4 063
1991	4 206	3 100	4 578	3 548	3 590	4 408
1992	4 342	3 331	4 533	3 547	3 611	4 199
1993	4 557	3 519	4 963	3 691	3 572	4 534
1994	4 500	3 426	4 693	4 045	3 754	5 064
1995	4 659	3 541	4 917	4 347	4 240	5 166
1996	4 894	3 734	5 203	4 214	4 396	4 628
1997	4 822	4 102	4 387	4 209	4 891	4 161
1998	4 953	3 685	5 268	4 293	4 470	4 600
1999	4 945	3 947	4 945	4 096	4 691	4 084
2000	4 753	3 738	4 598	4 007	4 509	4 012
2001	4 800	3 806	4 698		4 352	4 166
2002	4 885	3 777	4 924		4 470	4 016
2003					4 647	4 273

Source: China Statistical Yearbooks and statistics from the Hebei Provincial Government

Table 22. Higher yields in the surveyed areas in 2002 and 2003

		Relayed cropped	
		No	Yes
maize	Total production, kg	2 042	3 059
	Yield, kg/ha	7 000	6 728
wheat	Total production, kg	1 663	2 800
	Yield, kg/ha	5 938	5 877

Note: only few farmers are not conducting relayed cropping

Table 23. Evolution of the Average Purchase prices in current Yuan/ton and price ratios

	Absolute price			Price ratios		
	Corn	Cotton	Wheat	cotton/corn	cot/wheat	wheat/maize
1978	187	2 408	276	12,9	8,7	1,5
1980	227	3 099	326	13,7	9,5	1,4
1983	228	3 045	330	13,3	9,2	1,4
1984	596	6 527	876	10,9	7,5	1,5
1985	366	5 906	496	16,1	11,9	1,4
1986	442	6 696	590	15,2	11,3	1,3
1987	487	7 617	637	15,6	12,0	1,3
1988	548	8 352	782	15,2	10,7	1,4
1989	782	10 900	1 180	13,9	9,2	1,5
1990	729	8 900	1 049	12,2	8,5	1,4
1991	618	6 888	859	11,1	8,0	1,4
1992	665	6 058	880	9,1	6,9	1,3
1993	752	7 381	865	9,8	8,5	1,2
1994	1 056	11 727	1 152	11,1	10,2	1,1
1995	1 612	14 000	1 744	8,7	8,0	1,1
1996	1 491	14 000	1 756	9,4	8,0	1,2
1997	1 490	14 000	1 441	9,4	9,7	1,0
1998	1 579	13 000	1 298	8,2	10,0	0,8
1999	1 200	9 400		7,8		
2000	856	10 350	1 057	12,1	9,8	1,2
2001	967	7 571	1 050	7,8	7,2	1,1
2002	1 000	12 000	1 100	12,0	10,9	1,1

⁸ During the world market year of 2001, the cotton price corresponded to a historic low level which was transferred to the price applied in China

Such high level of price ratio in favour of cotton is not sustained by similar gap in terms of production costs. Since agricultural production is family-based in China, we are reluctant to integrate ex-ante valuation of the labour cost to fully assess the production costs. We hence limit ourselves to focus on the cash expenses engaged in the crop production and which are mainly represented by the fees paid for seeds and chemicals.

Owing to the fact that wheat and maize are sequentially grown, it could be somewhat misleading to assess the input costs on the basis of individual crop and this is particularly true with regard to fertilizing. Some fertilizers brought on the first crop, and this is the case for phosphorous fertilizers, are actually used also by the second one. Under this reservation and according to the results of our survey, maize appears to require far less cash expenses for the payment of inputs than wheat, but this is mainly due to the fertilizer costs. This outcome is consistent with the results provided by the surveys implemented steadily in China at provincial level: maize appears to be less demanding in input costs, although the gap is less large as the one we observed (0).

The input costs for growing cotton are quite close in the 2002 and 2003 campaigns and they are not really so much superior to the ones of wheat (Table 24). In the time series collected at the national level (0), the gap between cotton and wheat was larger -at the expense of cotton- than the one we observed: this could be related to the adoption of the cotton GMVs which reduced costs.

Table 24. Costs of the chemicals used in producing corn, cotton and wheat (Yuan/ha)

	2002	2003
Corn	1 220	1 432
Cotton	2 411	2 592
Wheat	2 547	2 192

Excessively favourable price ratio for cotton and reduced production costs are two converging items, in addition to some yield gain which is reported (Huang, et al., 2003a, Huang, et al., 2002a, Huang, et al., 2003c), which induce a great profitability gap at the expense of maize and wheat. This is observed through the results of our survey (Table 26) for the income net of the input costs of the recent campaigns and which is consistent with the statistics for the previous campaigns, in terms of added values⁹ (Table 27).

Owing to an insufficient profitability, the prospect of a re-launch of the cereal production in China, in particular in cotton zones, seems to be gloomy. This observation pushes some researchers to advocate the release of the GMVs available for various food crops in order to re-boost their productivity (Huang, et al., 2002b, Lin, et al., 2001). One may nevertheless

⁹ which take account of few other costs in addition to the input costs

doubt that this technology injection will be sufficient to reverse a process more structurally-based than usually considered.

Table 25. Evolution of the cash expenses (Yuan/ha)

	Corn	Cotton	Wheat
1978	339	564	378
1980	369	651	441
1983	441	820	499
1984	477	874	546
1985	495	856	576
1986	522	876	615
1987	611	1 005	684
1988	716	1 204	798
1989	906	1 494	1 010
1991	1 033	1 943	1 169
1992	1 062	2 034	1 286
1993	1 141	2 243	1 437
1994	1 650	2 954	1 895
2000	2 071	3 397	3 087
2001	2 053	3 343	2 401

Source: China Rural Statistical Handbooks & Nat. Cost of production survey

Table 26. Income net of the costs of inputs (Yuan/ha)

	2002	2003
Wheat	3 821	4 591
Maize	4 789	5 852
Cotton	11 798	17 093

Source: our survey

Table 27. Evolution of the added value in growing corn, cotton and wheat (Yuan/ha)

	Corn	Cotton	Wheat
1980	608	1 601	407
1983	783	2 712	666
1984	1 026	2 813	935
1985	1 010	2 335	872
1986	1 201	2 712	957
1987	1 188	3 120	871
1988	1 163	2 769	840
1989	1 217	4 203	904
1991	1 246	6 026	786
1992	1 616	3 508	1 150
1993	2 744	5 071	1 592
1994	3 536	9 123	2 362
2000	2 783	9 190	1 767
2001	3 828	7 000	2 040

Source: China Rural Statistical Handbooks & Nat. Cost of production survey

5. Limited impact foreseen from the release of GMVs on food crops

5.1. *Risk of over-estimating impacts and productivity gap too large to catch up*

As mentioned above, the Chinese research institutions carried out many GMVs for food crops, in particular cereal crops like rice, wheat and maize. China can claim the full ownership of these varieties since many genes have been discovered or result from specific construction by its research teams. These genes provide various types of resistance to harmful insects, to

diseases or to virus. There is a potential to cut the production costs and/or to increase the yield achieved so far. Through the example of the gains obtained on cotton by the use of GMVs, there is ex-ante assessment of the gains which could result from the release of GMVs on food crops. The models used integrate the estimation of the negative effects that might result from the non-acceptance of the GM-commodities by foreign consumers. It is concluded that the Chinese Government should stop blocking the release of the GMVs for the food crops and not over-emphasizing the risk of non-acceptance by the foreign markets (Huang, et al., 2002b, 2003b).

As with any model, the outcomes depend a lot on the assumptions of the anticipated effects. In case that the positive effects on cost reduction and/or yield increase is over-estimated while the negative effects are under-valued, the anticipated global effect could be very much exaggerated. With regard to the extrapolation of the positive impact observed on cotton production to the food crop production, it is worth reminding that cotton growing is more depending on the pesticide use and the yield is very sensitive to distortion to a non-optimal pest control. The first factor is at the basis of the cost reduction observed while the second factor explains the yield gain which was not anticipated firstly by the promoting firms of GMVs. As far as GMVs are not tested at large scale in China on food crops, it is difficult to determine the real scope of the positive effect being anticipated.

In addition, the structures of the production costs are not the same between cotton in one hand and wheat or maize in the other hand (Table 28). The recourse to pesticides is far lower in producing maize and wheat in Hebei Province. What was materialized in the cotton production in terms of cost reduction and yield increase might be minimal on cereal crops as far as pest resistant GMVs are concerned. The cost in fertilizing is quite high: the real challenge is to achieve better economic efficiency in using fertilizers. Probably, in the mid-term, new GMVs enabling better mineral uptake will help. But in the short term, better information on the fertilizer use, in order to prevent over-dosage as it was observed through the rice case (Huang, et al., 2000), should lead more certainly to positive financial and environment impacts.

Table 28. Differentiated Structures of the costs in using chemicals (Yuan/ha)

	2002			2003		
	Cotton	maize	wheat	Cotton	maize	wheat
Pesticide costs	566	40	34	533	105	91
Fertilizer costs	820	477	1 261	876	695	1 080
Total cost of chemicals	1 386	517	1 295	1 410	799	1 171

Source: our survey

In the opposite side, there is a great risk of down-sizing the negative effect resulting from the

refusal of GM commodities or GM-made agro-foods since the refusal could be total and not only partial.

While dealing with the issue of acceptance/refusal of GM-based commodities or agro-foods from China, it is common to take only the foreign market into account. This could be too much a simplification and leads to erroneous conclusion. It is up to the Chinese tradition to associate food with health. The recent episodes of SARS and mass contamination of poultry in South East Asia, and in particular in China, remind that the way of producing food can impact directly on public health.

The negative reaction of the Chinese consumers cannot be overlooked with regard to the threat of GM-foods on health. The environmental and ecology concern is no longer ignored by the Chinese population so that how safe GM-food might be is debated (Anon., 2001c, 2002, 2004, Zhu, et al., 2000). Greenpeace is becoming very active in China and is supporting some customers' claims against food industry including the world giants in this sector (Anon., 2002, 2003a)}. The concept of "Green Food" already attracts attention and helps to capture a market niche. China decided, more than one year ago, the labelling of GMO content in foods (Anon., 2003b) and this country is having legislation quite close to the one of the European Union. As far as we know, there are no models which take the risk of non-acceptance in China into consideration. This is a factor of over-estimating the positive impacts from the release of GMVs on food crops while some surveys already points out that 100% acceptance by Chinese consumers is not at all guaranteed (Asian Food Information Centre, 2004).

The extent of the adoption of GMVs on food crops might also be less important than what is observed for cotton. The basic reason lies upon the fact that most of the food crops have not experienced the levels of infestations (by insect, disease or virus) which endangered their production and made them very little effective. On cotton, the chock which resulted from the severe pest resistance to some insecticides was so strong that farmers were in the expectation of a new technical solution. One cannot claim that the situation is similar for most of the food crops. This is then another risk of over-estimating the positive impact from the use of GMVs. Probably the release of the GMVs on food crops will help to achieve profitability gain. But the gain needed should be so much large that this release might not be sufficient to reverse the current trend of withdrawal from cereal production. So far, the added value from growing cotton is at least twice the one from wheat or maize. In the short run, we doubt that GM maize or wheat could catch up such a gap. This sounds further difficult if we consider that the first generation of GMVs on maize or wheat will have to compete with cotton GMVs which pertain already to the second generation (combining various genes). This pessimism should

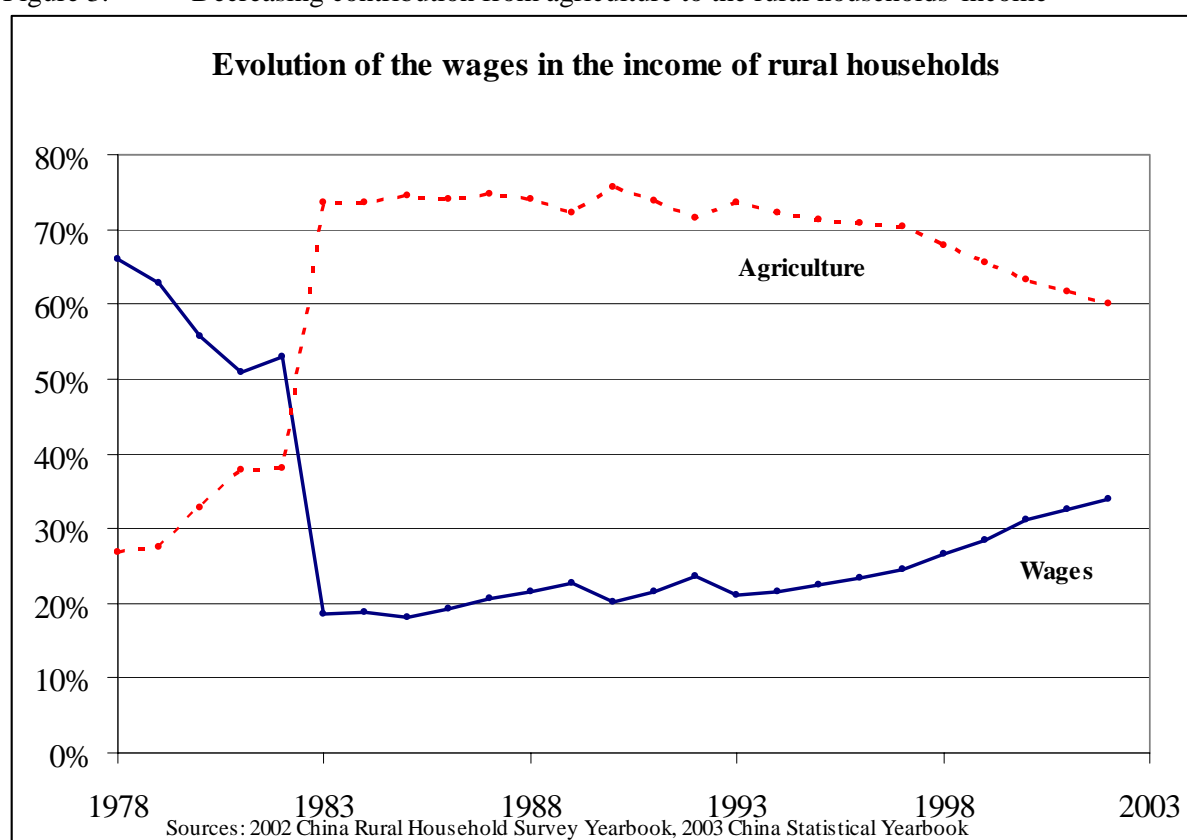
nevertheless be balanced by the hardship in growing cotton, in terms of labour demand at the harvest stage, and in the implementation of the chemical sprays.

5.2. *A structural phenomenon beyond technical solution*

We believe that the process of reduction in the cereal production is just a signal of a more structural process corresponding to the loss of terms of trade at the expense of the agricultural goods. This process impacts now more strongly on the cereal production but the injection of a new technology should be insufficient to counter the process in operation.

As shown in the Figure 2 above, the income of the rural households is lagging behind the one of the urban population. Furthermore, it comes out that the agricultural activities account less and less in the income of the rural households (Figure 3). By increasing the profitability in the production of maize and wheat, the global result will be to reduce a decreasing trend but likely not enough to reverse this trend. Is this approach worthwhile? Could this approach hamper the materialisation of more promising solution? These are two major issues that should be addressed before any precipitation.

Figure 3. Decreasing contribution from agriculture to the rural households' income



The Chinese Government seems to have a right understanding of the issue of reduced cereal production, in particular in the regions known as the traditional cereal producing areas of the country. For the first time, this government issued an official policy document devoted

specifically to increase the farmers' income in these areas. The new policy is widely publicized as it was extensively reproduced in all the major newspapers in the country and a specific press conference was organized to help understand the basic principles of the policy (XinHua Web, 2004).

It is noteworthy that the income increase is regarded as the cornerstone of the agriculture policy instead of the output objectives as it is still commonly the case. It is considered that without taking into account the farmers' income purpose, it would be inefficient to expect improving the agriculture outputs.

We can consider that the whole policy lies upon four major principles. One is to implement a reduction of the taxes the farmers are subjected to so far. The agricultural tax is reduced 1% while the tax for special agricultural production is suppressed. The second principle is to sustain the farming profitability through the increase of the farm tenure size. In this regard, the liberalization of the land market is expected to achieve a better use of the land, under the reservation that some land must remained preserved and not open to economic production. The third principle is to sustain the farming productivity through more investment in agriculture. The fourth principle is to further increase the involvement of the farmers' population in the 2nd and 3rd economic sectors (processing and service sectors), by making these sectors furthermore developed and better assisted by the banking system.

The development of the processing industries in rural areas appears to be of paramount importance in order to absorb the labour surplus. It is emphasized to further transform the agricultural products and to move towards their regional labelling in order to achieve higher added value and satisfy the consumers' requirements. Out of China, quality and quality labelling appear to be incompatible with GM content. If the same antagonism prevails in China, the release of GMVs on food crops might seriously threaten the achievement of the new national objective. The Chinese Government is still very prudent with regard to the GM food crops and GM-foods (Anon., 2001b). We think that this is rather in line with the evolution of the Chinese population's concern regarding food quality. It is consistent with the general objective of increasing the rural incomes through further processing agricultural commodities into foods and through the approach of meeting the consumers' demand for quality and safety.

6. Conclusion

In this paper, we provide confirmation of the trend that China is becoming somewhat dependent on international market for feeding itself. In quantitative terms, China is not producing enough cereals for itself. This trend is exacerbated by the emergence of GM use,

since this use is still prohibited for foodcrops. Should this issue be regarded under dramatic terms? There is no developed country which is totally independent on all of its feeding needs. There is then not so much justification to seek full independency. We think that the interdependency between countries is a reality, furthermore when countries have achieved some extent of economic development.

China provides a positive evidence of the use of GMVs by family small holdings in a profitable way. This is opposite to the analysis anticipated by many NGOs because the Chinese farmers benefit from specific and favourable rules. This achievement cannot be extrapolated automatically to other developing countries.

China offers a very interesting case of GM management. The availability of GMVs does not mean necessarily indistinct use of GMVs. The evidence of profitability in using GMVs for some crops does not lead necessarily to the extension of their use on other crops. In China, the issue of releasing the GMVs on foodcrops is under debate. It seems that researchers are in the pro-side, while the government seems to be in the con-side: this is a rather uncommon situation worthwhile to underline. It seems that the current debate is opposing the quantitative approach to the qualitative approach. The fact that the Chinese government is paying concern to the qualitative aspects is an indication of the level of economic development China has achieved.

To us, the caution in postponing the decision of the GM diffusion to food crops remains justified. The extrapolation from the cotton case to food crops deserves deeper insight: the economic impact for the farmers might not be as high as with cotton. The concern related to the GM-food used to be regarded as specific to foreign consumers but it could be a mistake not to pay attention to the reaction from the internal market. Chinese population is very sensitive, by tradition, to the health impact of foods. They might share the foreign concern if this latter appears founded. Besides, the new policy of promoting more food processing and to move towards labelling agro-foods, as an orientation to generate more jobs and higher added value in the rural areas, might question the relevance of launching GMVs for food crops.

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